Lecture 2: Chapter 25, August 30

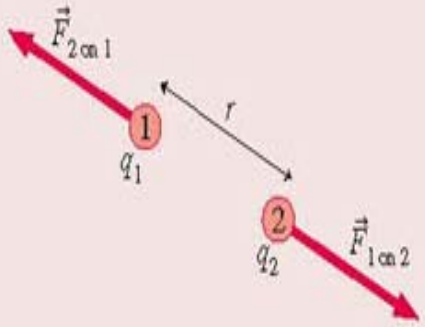
Coulomb's Law

GENERAL PRINCIPLES

Coulomb's Law

The forces between two charged particles q_1 and q_2 separated by distance r are

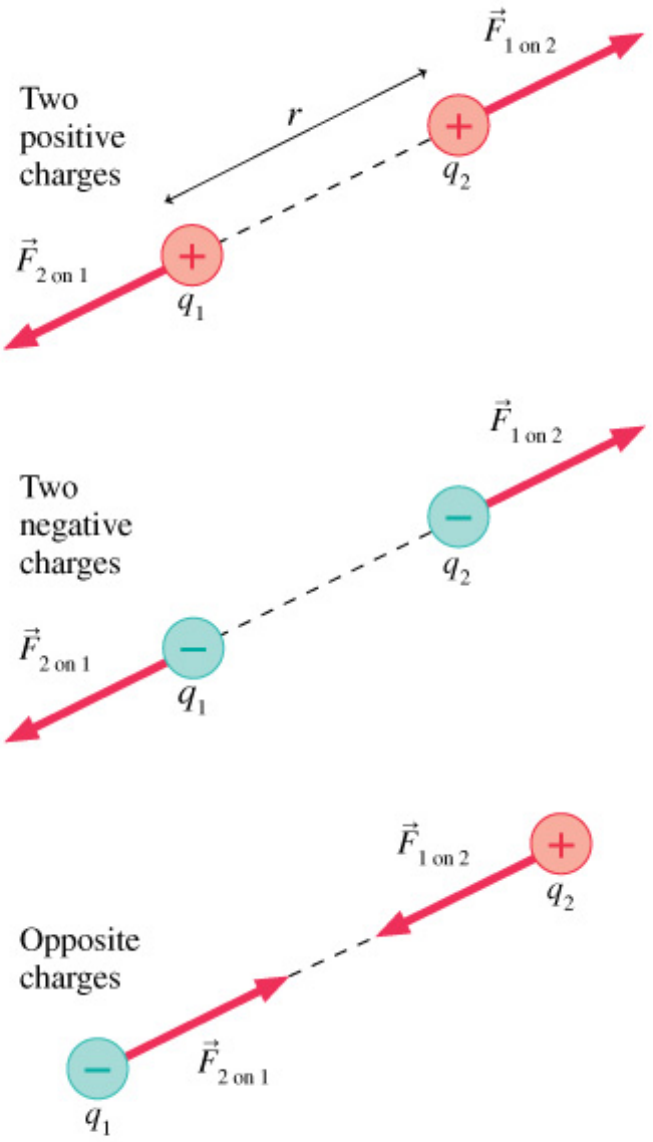
$$F_{1\text{ on }2} = F_{2\text{ on }1} = \frac{K|q_1||q_2|}{r^2}$$



These forces are an action/reaction pair directed along the line joining the particles.

- The forces are repulsive for two like charges, attractive for two opposite charges.
- The net force on a charge is the sum of the forces from all other charges.
- The unit of charge is the coulomb (C).

An important difference with Newton's law



The forces can be attractive or repulsive depending on the signs of charges

Units of Charge

The SI unit of charge, one coulomb (C), is derived from the SI unit of current (A) (to be studied later).

Two equivalent forms of Coulomb's law

$$F = K\frac{|q_1||q_2|}{r^2}$$

Easy to remember constant K:
$K = 9.0 \times 10^9$ N m^2/C^2

$$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$$

Constant ε_0 will be used in future:
$\varepsilon_0 = 1/(4\pi K) = 8.85 \times 10^{-12}$ C^2/N m^2

Once we fixed a unit for q: $e = 1.6 \times 10^{-19}$ C
Note: during rubbing q is ~10^{-9}-10^{-7} C.
How many electrons moved?

PROBLEM-SOLVING STRATEGY 25.1: Coulomb's law

MODEL Identify objects that can be modeled as point charges.

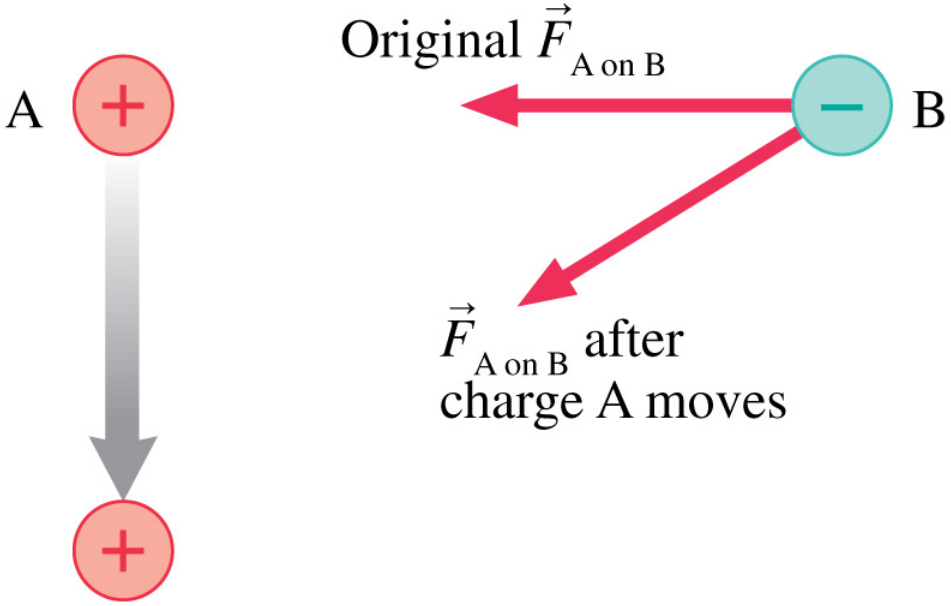
VISUALIZE Use a *pictorial representation* to establish a coordinate system, charges, forces, distances and angles.

SOLVE Use Coulomb's law

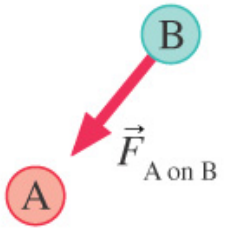
- Show the directions of the forces on the pictorial representation.
- When possible, do graphical vector addition.
- Write each force vector in terms of its *x*- and *y*-components, then add the components to find the net force (take into account the signs).

ASSESS Check that your result has the correct units, is reasonable, and answers the question.

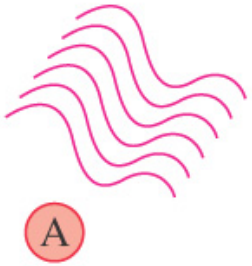
The Concept of Field



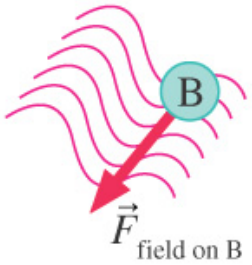
If charge A moves, how long does it take the force on B to respond?



In the Newtonian view, A exerts a force directly on B.



In Faraday's view, A alters the space around it. (The wavy lines are poetic license. We don't know what the alteration looks like.)

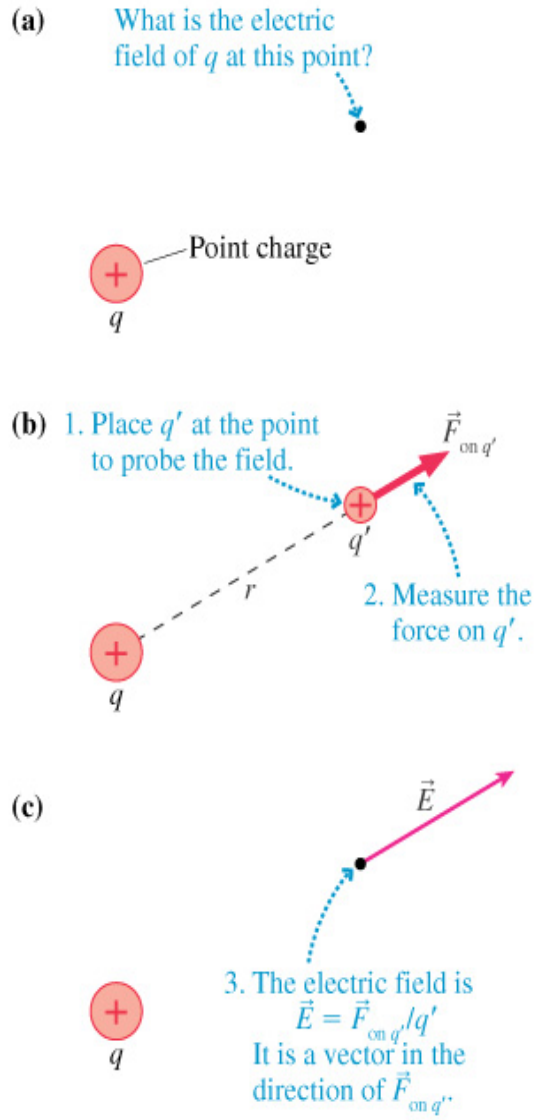


Particle B then responds to the altered space. The altered space is the agent that exerts the force on B.

The Concept of Field

$$F_{1\text{ on }2} = F_{2\text{ on }1} = \frac{K|q_1||q_2|}{r^2} \qquad (25.2)$$

$$\vec{E}(x, y, z) = \frac{\vec{F}_{\text{on } q} \text{ at } (x, y, z)}{q} \qquad (25.11$$

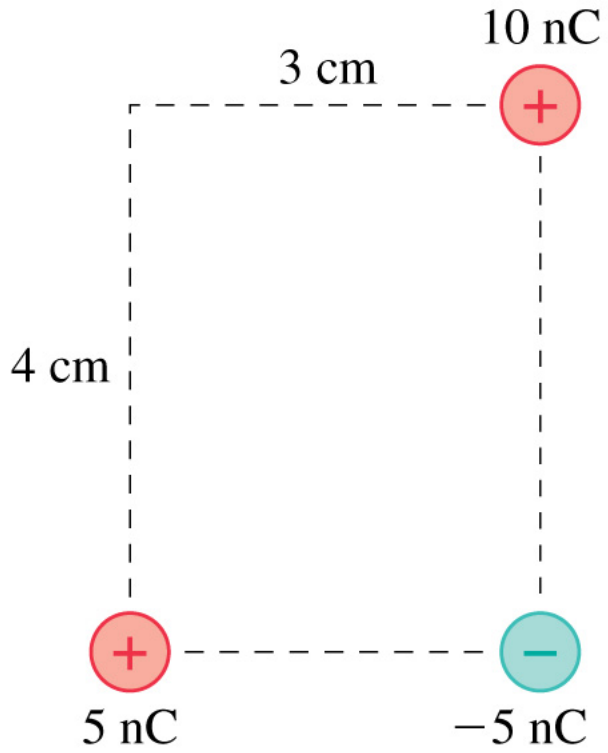


Force depends on "source" and "probe" charges

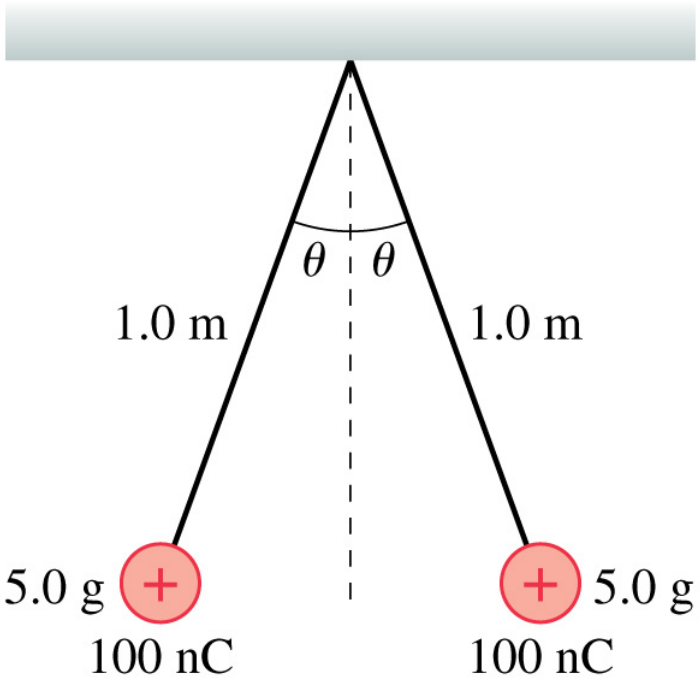
By dividing *F* by the "probe" charge we defined the el. field

Problems solved in the class, Chapter 25

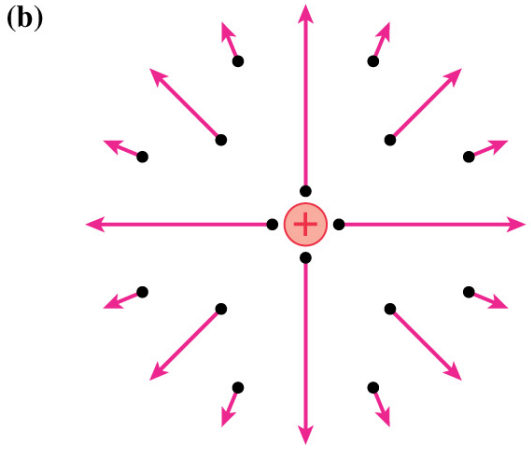
Problem 42



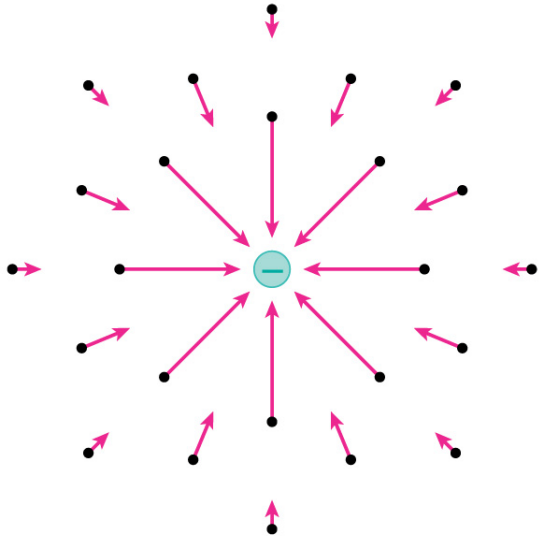
Problem 59



Unit Vector Notation



The electric field diagram of a positive point charge



$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r} \qquad \text{(electric field of a point charge)} \qquad (25.15)$$

r with a "^" is the unit vector from the charge to the point at which we want to know *E*

End of Lecture 2
Reading: Entire Chapter 25, Preparing for Quiz1 (see the review)
Home Work 1 in Mastering Physics